Analysis of a Terrain Enhanced Precipitation Event across Upper Michigan

2008 Great Lakes Operational Workshop

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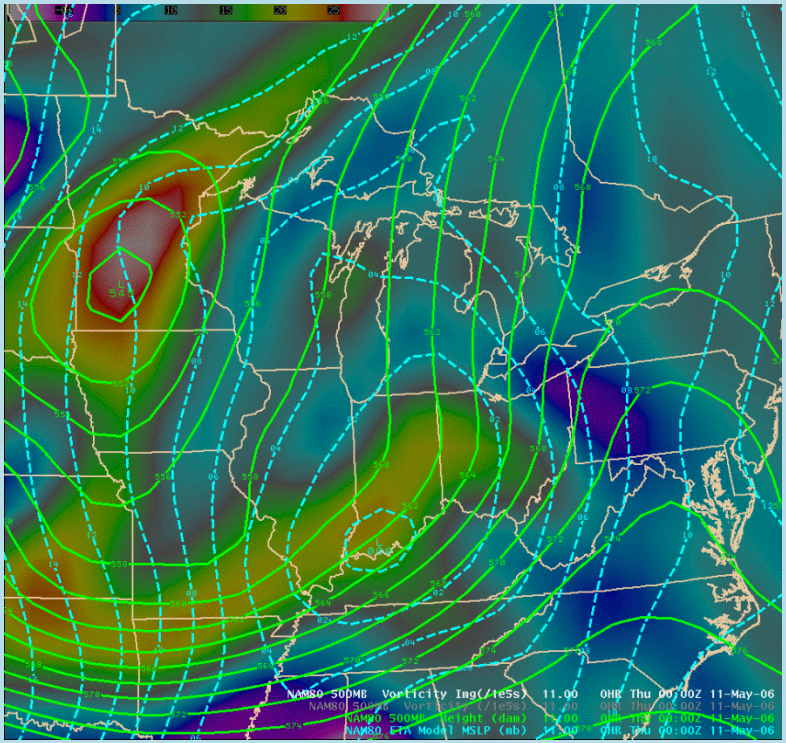
Overview

- On May 11th and 12th strong low pressure moved from the southern Indiana, began to occlude and move to near Ludington, MI where it stalled.

- As the low stalled the occluded portion of the system moved into Upper Michigan during the afternoon and evening hours of May 11th.

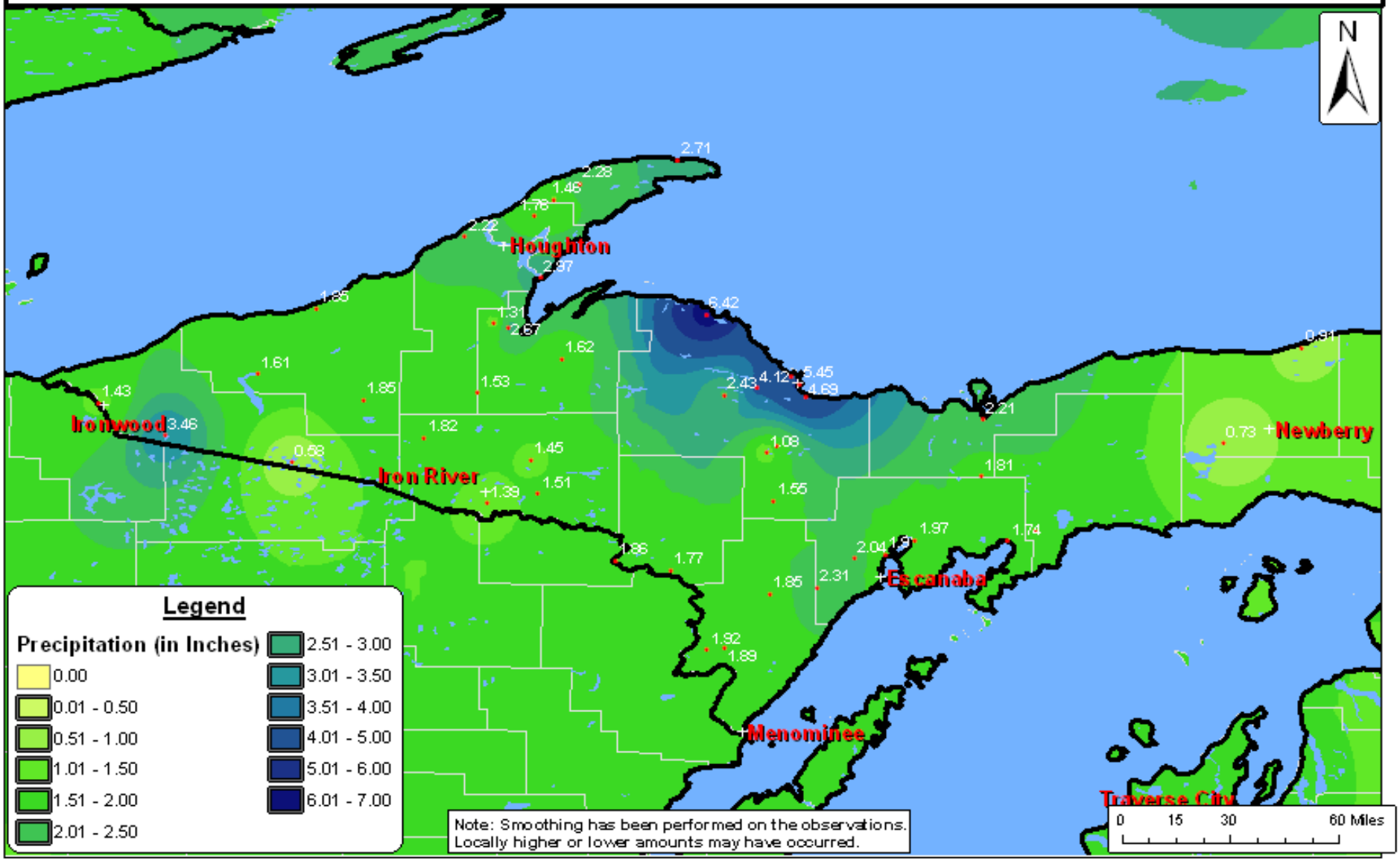
- This resulted in heavy precipitation across portions of north central Upper Michigan over a period of approximately 27 hours.

- Intense heavy rainfall led to localized flooding.
  - 15Z May 11th to 03Z May 12th
  - Numerous road washouts
    - Including portions of US-41
      - As well as many secondary roads
    - Mudslides
      - Along CR-550



Upper Michigan Precipitation

May 13, 2006



Legend

Precipitation (in Inches)

- 0.00
- 0.01 - 0.50
- 0.51 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 2.50
- 2.51 - 3.00
- 3.01 - 3.50
- 3.51 - 4.00
- 4.01 - 5.00
- 5.01 - 6.00
- 6.01 - 7.00

Note: Smoothing has been performed on the observations.
Locally higher or lower amounts may have occurred.

Why study this event?

- Heavy rainfall events across Upper Michigan are not common.
  - Especially those that cause flooding.
  - More typical of the Marquette County Warning Area (CWA) is snowmelt flooding along with rain which can exacerbate the situation.

- This event was complex.
  - Heavy late season snow/mixed precipitation
    - Winter weather headlines
  - Wind
    - Marine/Land wind headlines
  - Heavy Rain
    - Hydrology issues.

- Our office missed an important part of this event.
  - The intense heavy rainfall which lead to flooding.

- The goal of this presentation is provide an overview of the event.
  - Synoptic Overview
  - What might have been missed?

So, how was the forecast?

Forecast

- Shifts prior to the event noted the following:

Excerpts from 320 AM May 11th, 2006 Area Forecast Discussion

…MAIN FCST CONCERNS THIS PACKAGE REVOLVE ARND TIMING/IMPACT OF LO PRES IN THE OH VALLEY AND GOING HEADLINES…

…GIVEN STRENGTH OF DYNAMICS/ LLVL WINDS AND UPSLOPE/ADVECTIVE COOLING...LIKE THE GFS IDEA OF **COOLING THE TROF ENUF TO CAUSE RA TO MIX WITH OR CHG TO SN THIS AFTN OVER THE AREA**…

Excerpt from 1133 AM May 11th, 2006 Area Forecast Discussion

…MODELS SHOWING COLD AIR ADVECTION AROUND 900MB MAINLY OVER THE WEST TONIGHT. THESE TEMPERATURES WILL DROP TO WELL BELOW ZERO. **THUS EXPECT SNOW AND POSSIBLY SOME FREEZING RAIN…**

Forecast (cont.)

Excerpts from 414 PM May 11th, 2006 Area Forecast Discussion

…MAIN FCST ISSUES ARE **ONGOING HEADLINES** AND PCPN TRENDS OVER THE NEXT 24HRS…

…TO THE SE...THERE IS STILL A DECENT AREA OF PCPN WRAPPING N ACROSS THE CNTRL LAKES REGION...SO THERE WILL LIKELY BE WIDESPREAD COVERAGE OF PCPN FOR MUCH OF THE NIGHT OVER MOST OF THE FCST AREA**. PTYPE AND ESPECIALLY SNOW AMOUNTS WILL CONTINUE TO BE DIFFICULT TO GET A HANDLE ON…**

Forecast (cont.)

- Forecast focused on precipitation types/amounts and wind issues over Lake Superior.
  - Though it should be noted these phenomena were well forecasted.

- Forecasts did not mention potential for intense heavy rainfall or flooding threat.

Forecast (cont.)

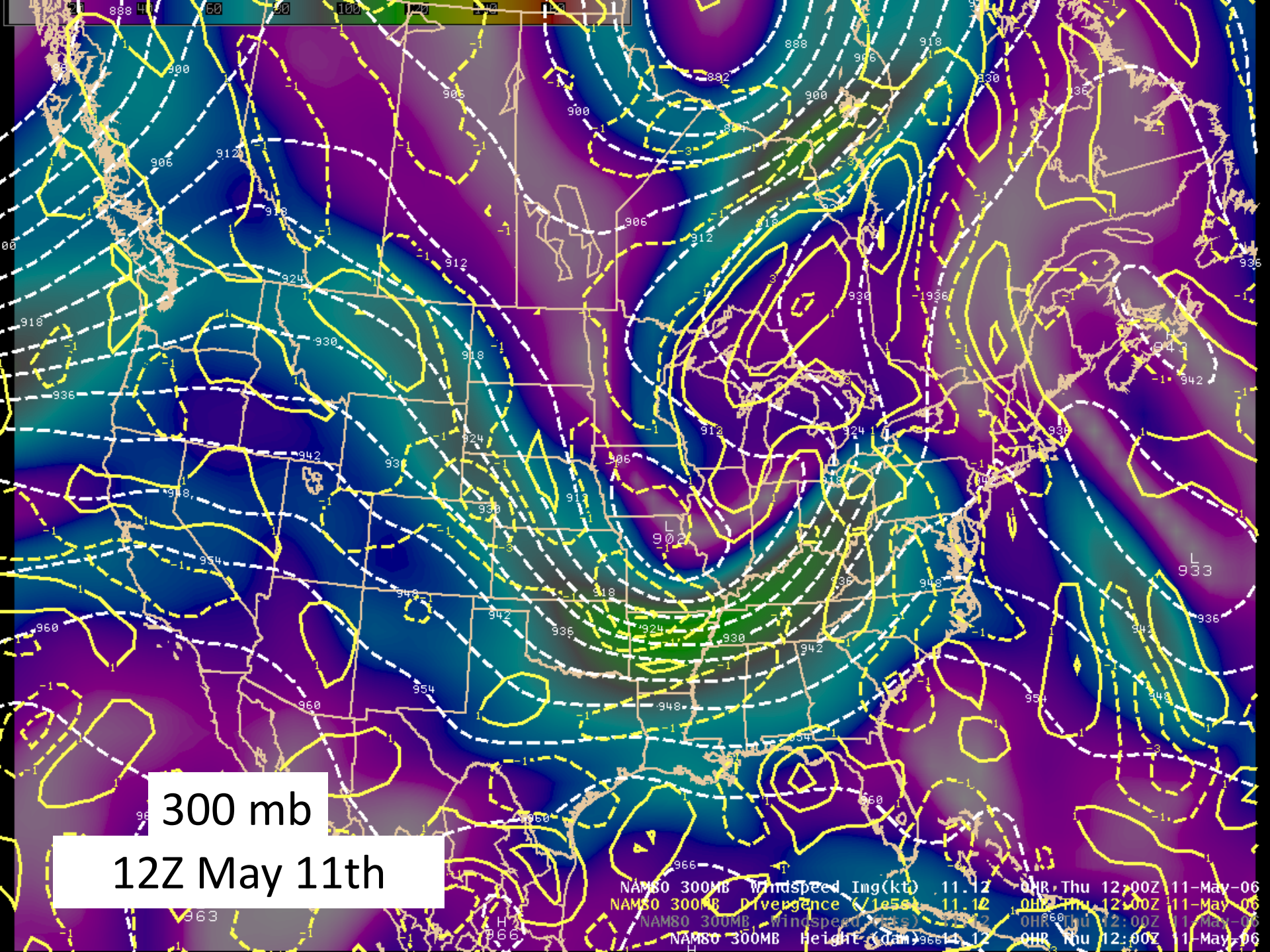
- What was missed?

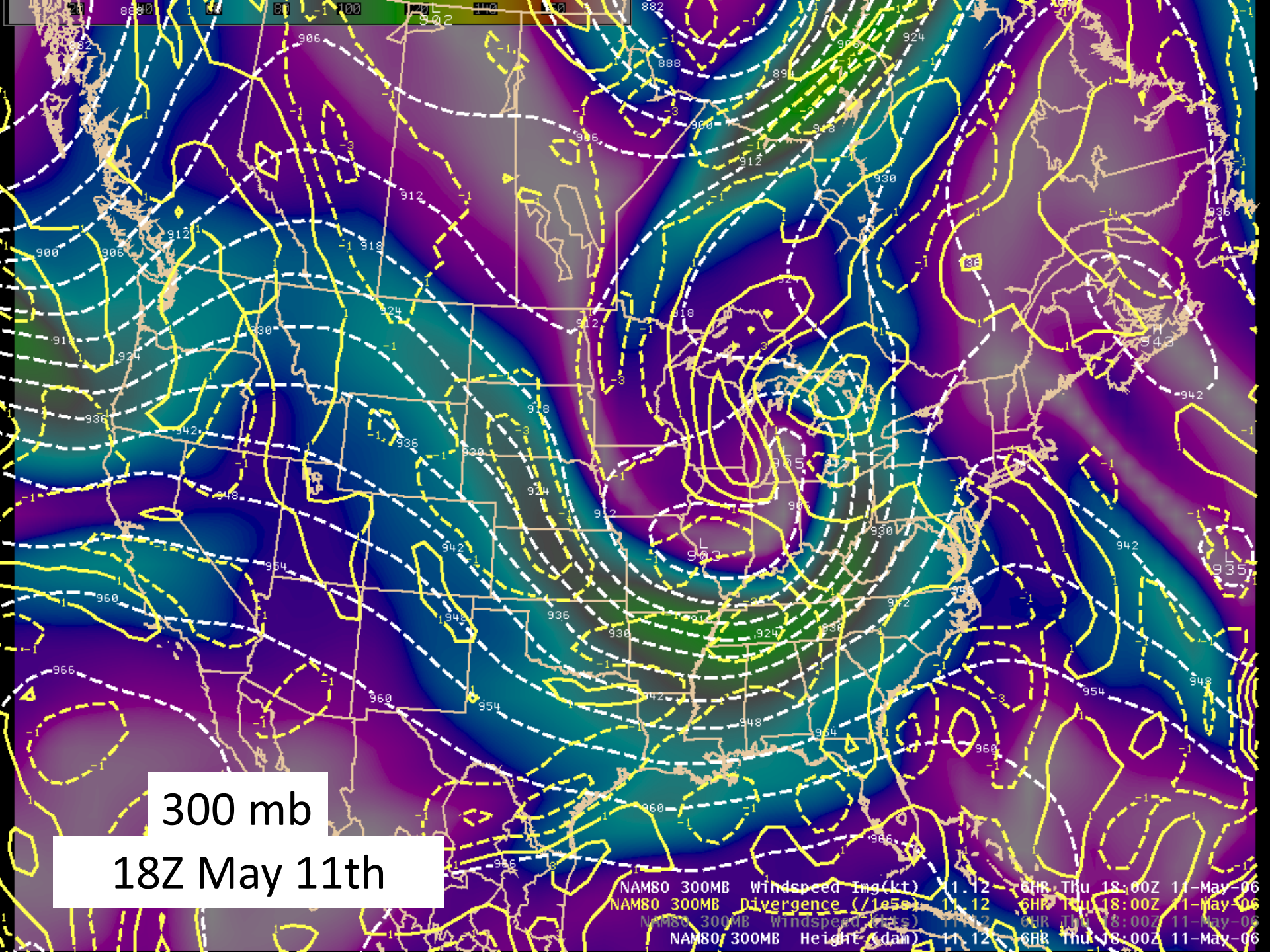
- Forecasters did not recognize intense heavy precipitation potential.
  - Heavy precipitation indicators

- Also some non-meteorological factors may have come into play.
  - More on this later.

Synoptic Overview

300 mb


300 mb
12Z May 11th
NAM80 300MB Windspeed Img(kt) 11.12 0HR Thu 12:00Z 11-May-06
NAM80 300MB Divergence (/1e5s) 11.12 0HR Thu 12:00Z 11-May-06
NAM80 300MB Windspeed (kts) 11.12 0HR Thu 12:00Z 11-May-06
NAM80 300MB Height (dam) 11.12 0HR Thu 12:00Z 11-May-06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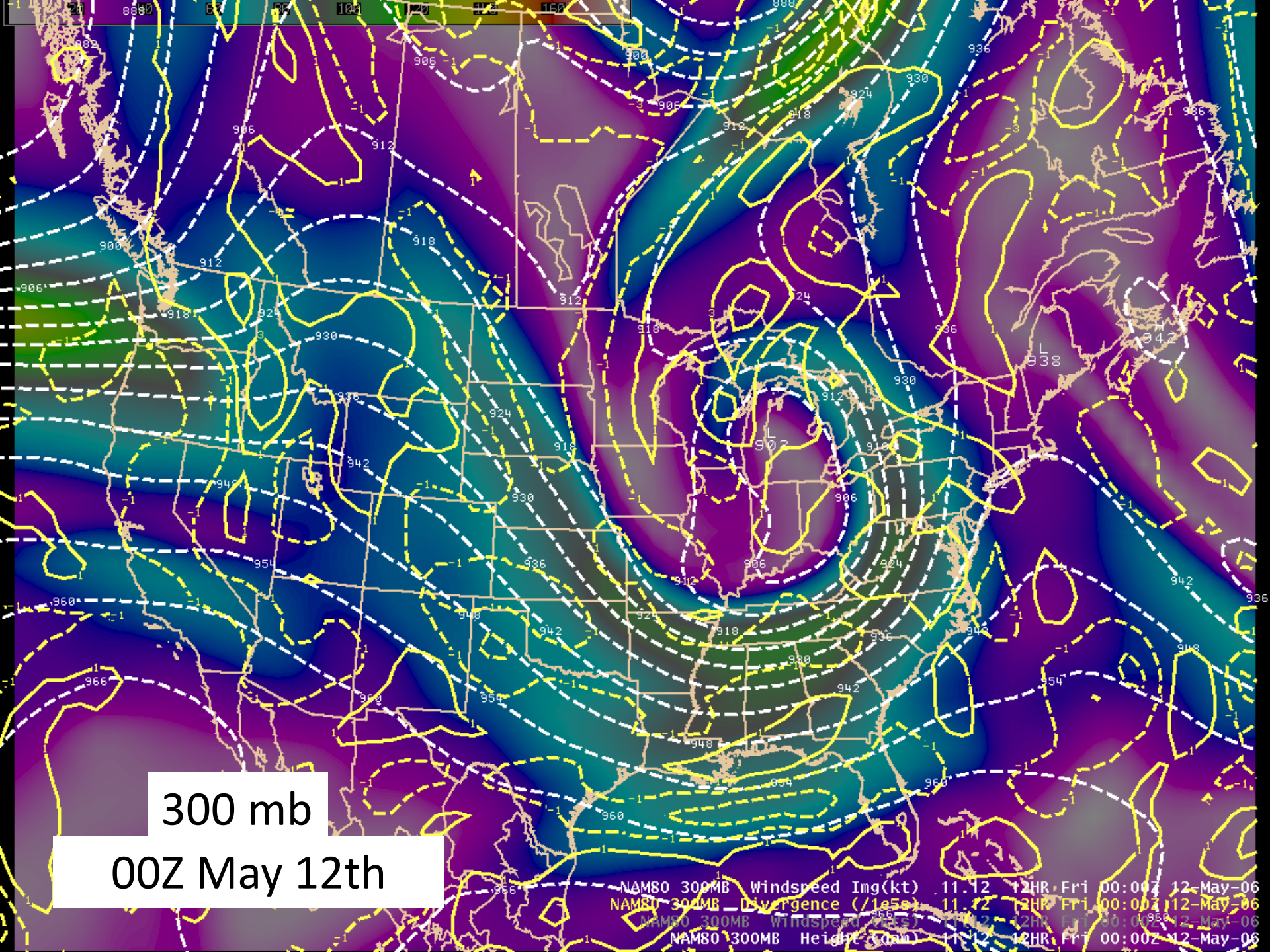
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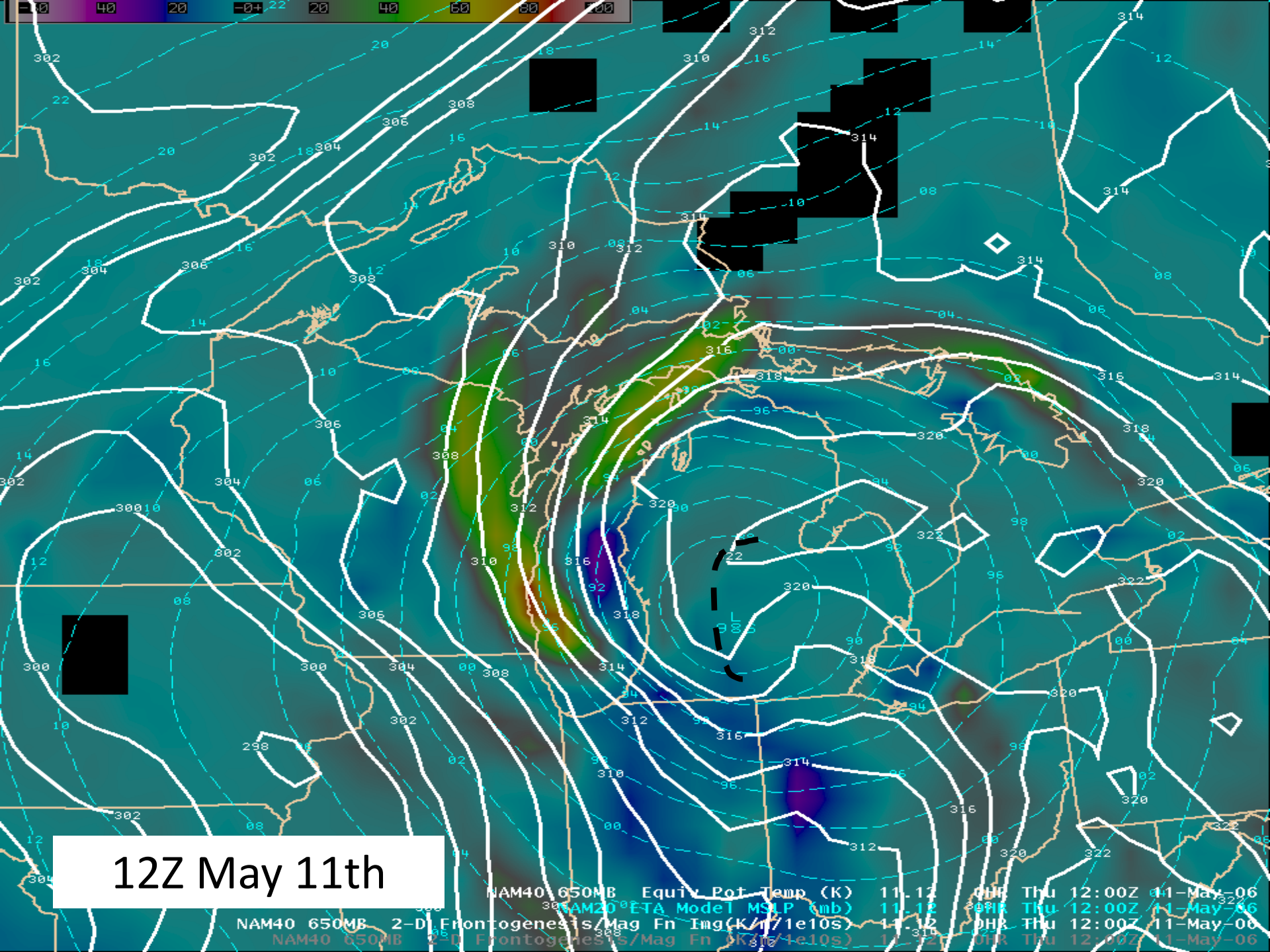
NAM80 300MB Height (dam) 11.12 12HR Fri 00:00Z 12-May-06

650 mb
F-Gen/Theta-E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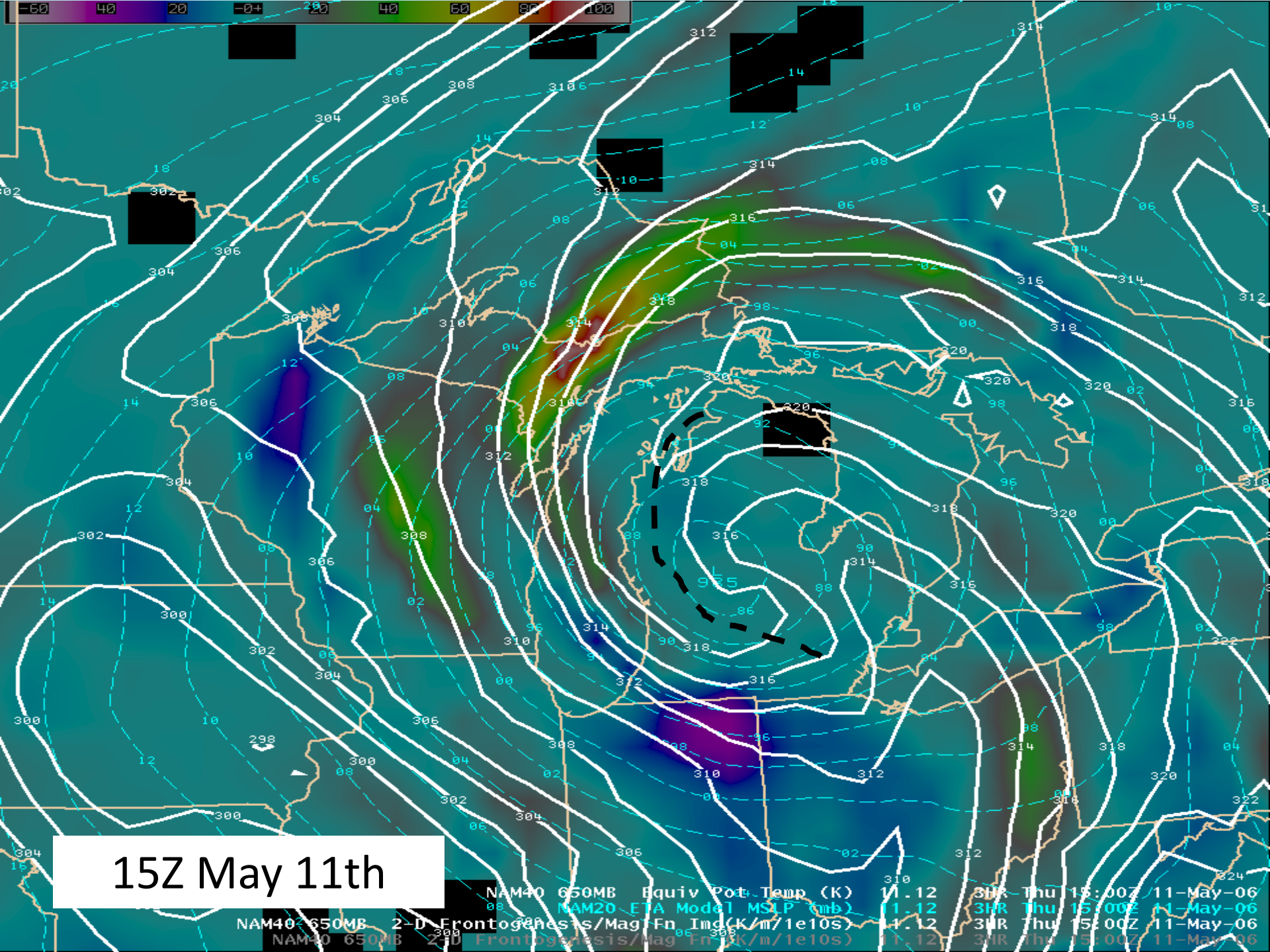
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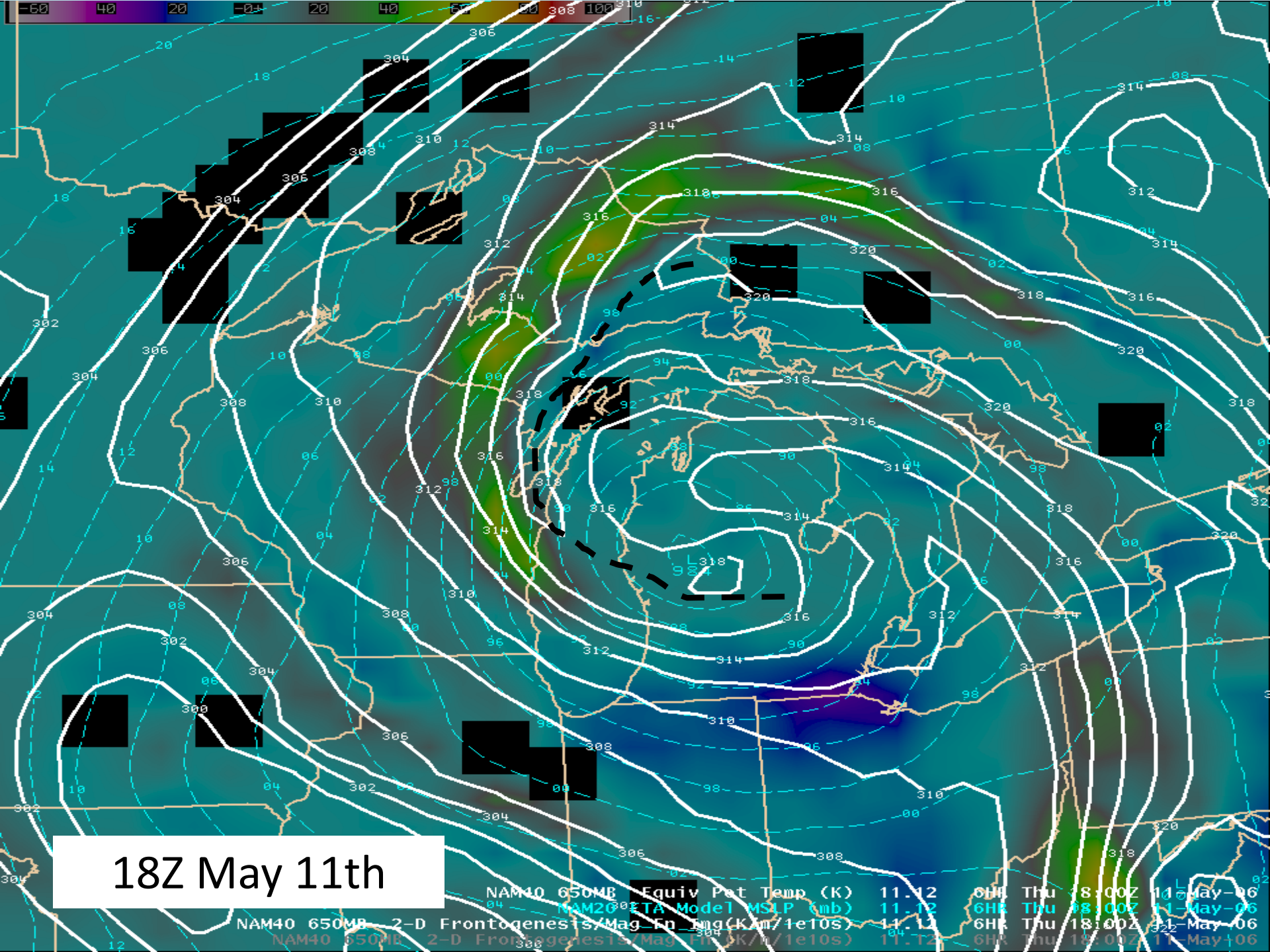
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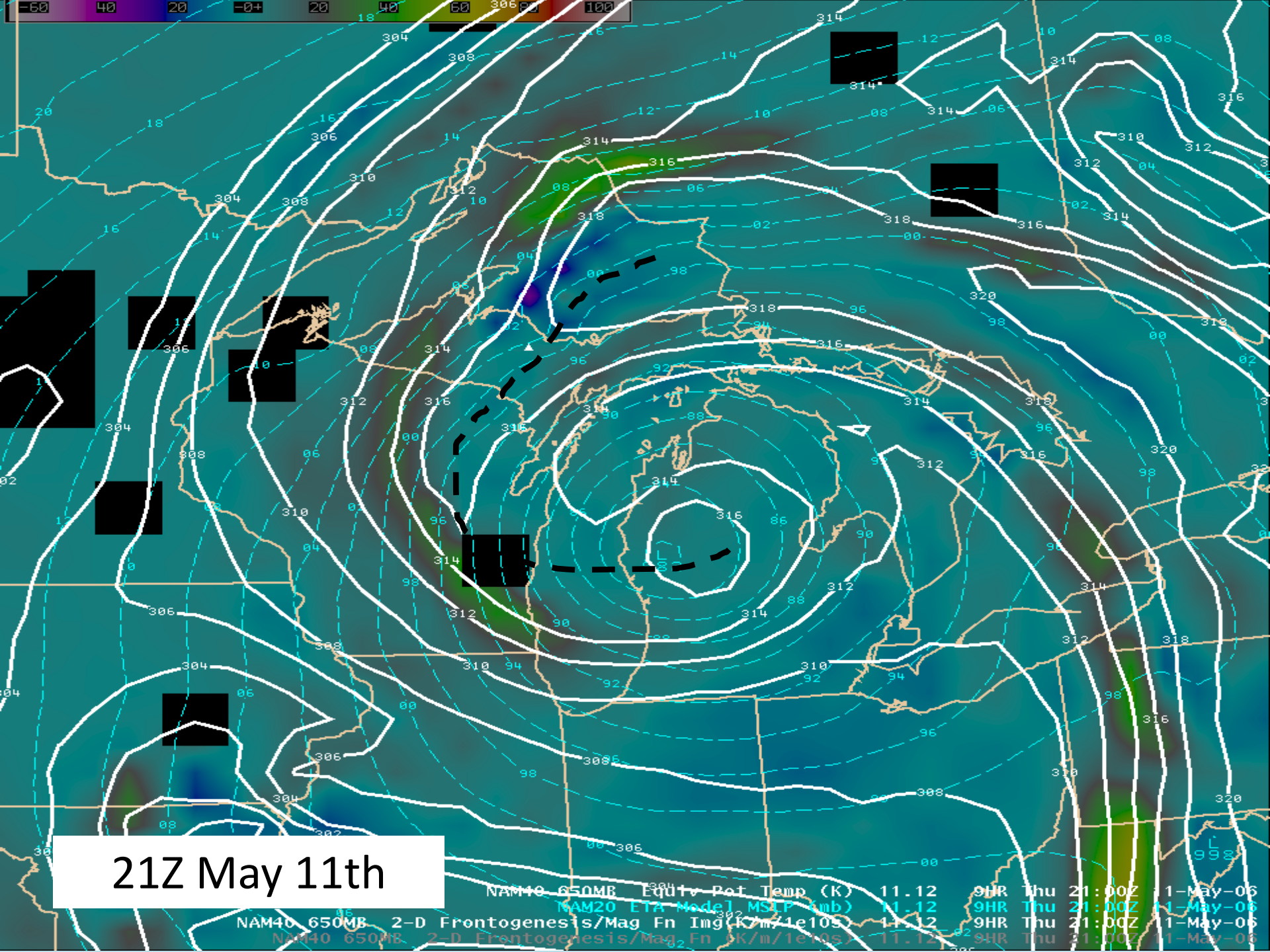
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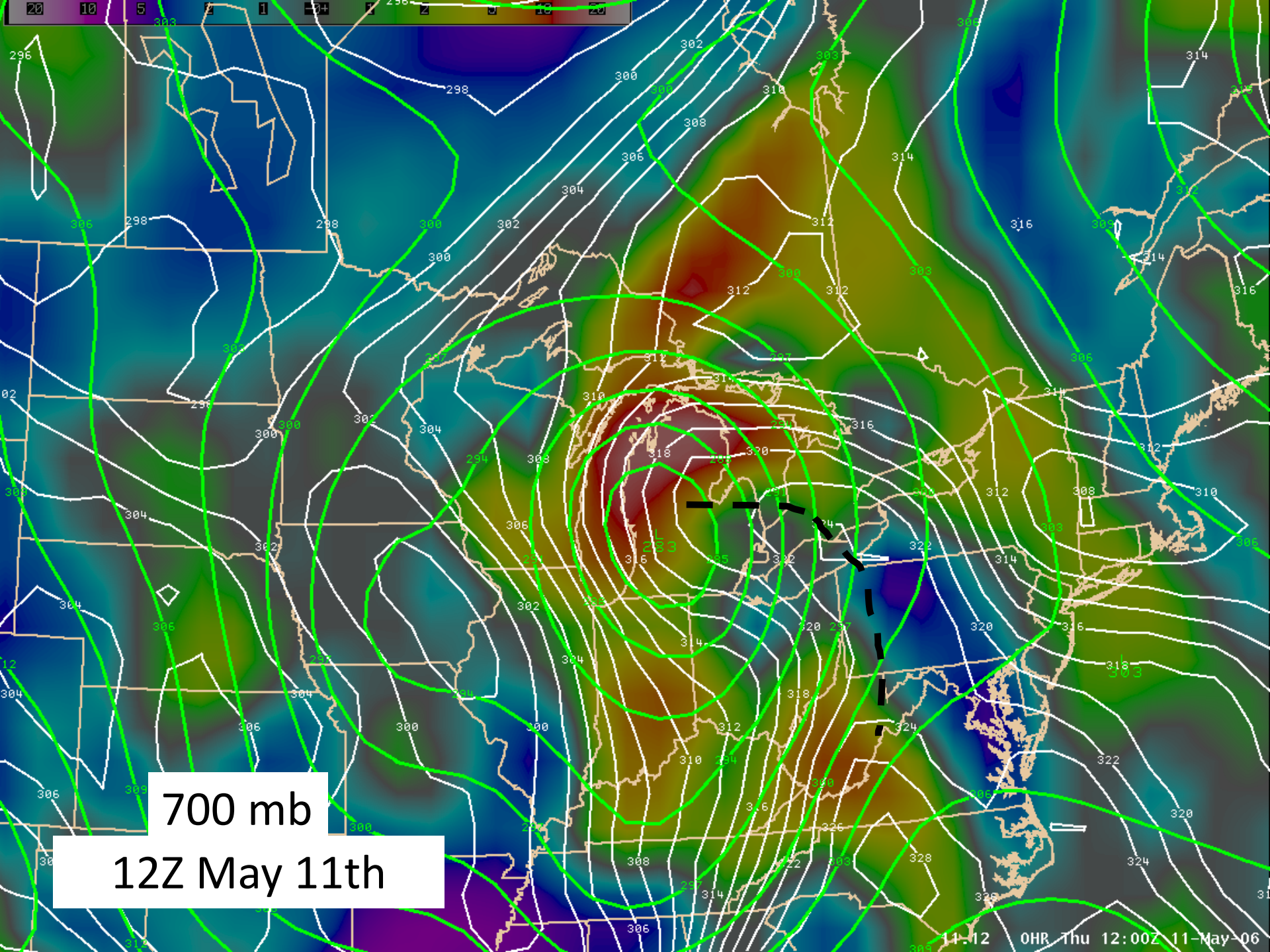
700 mb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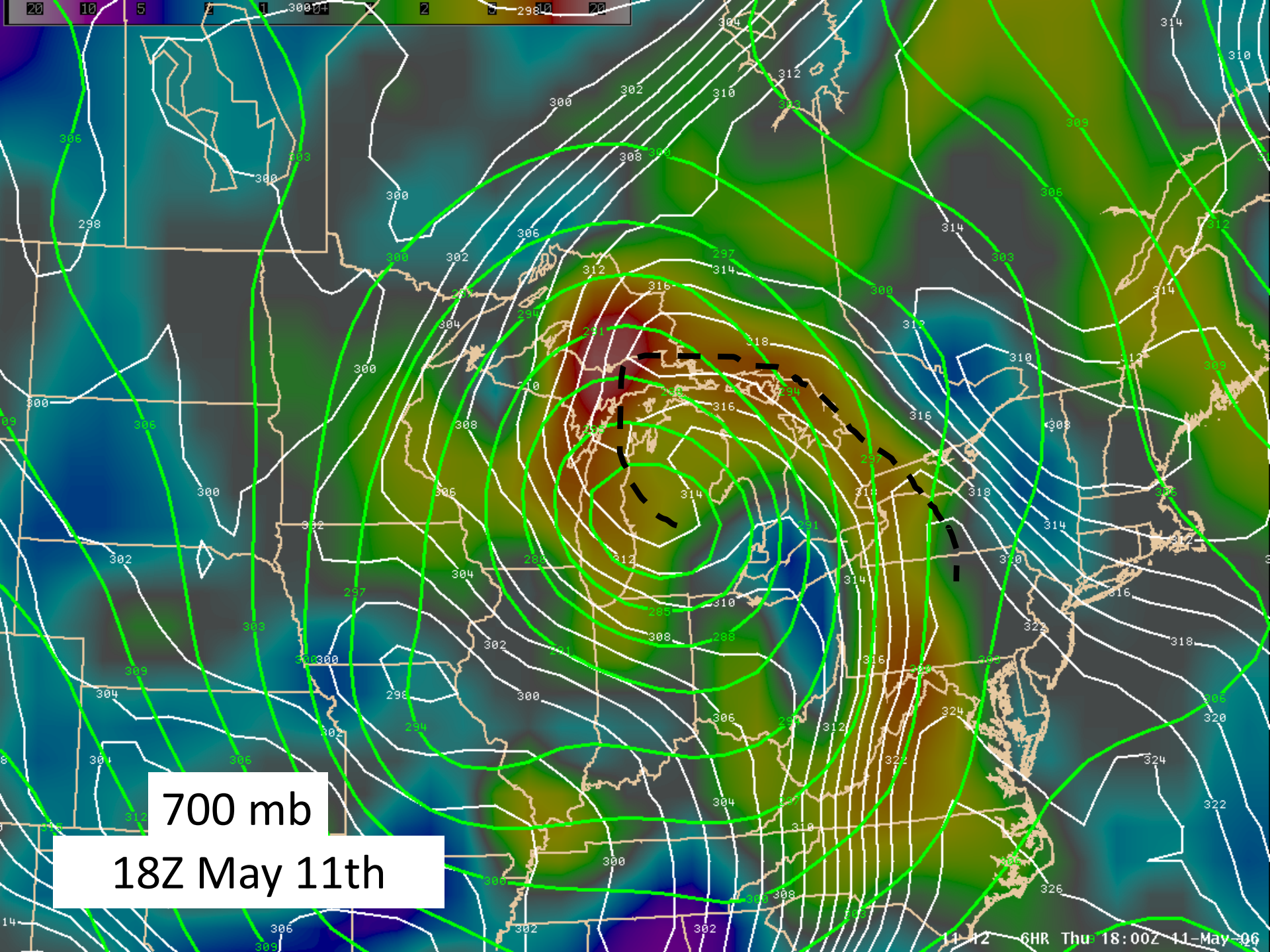
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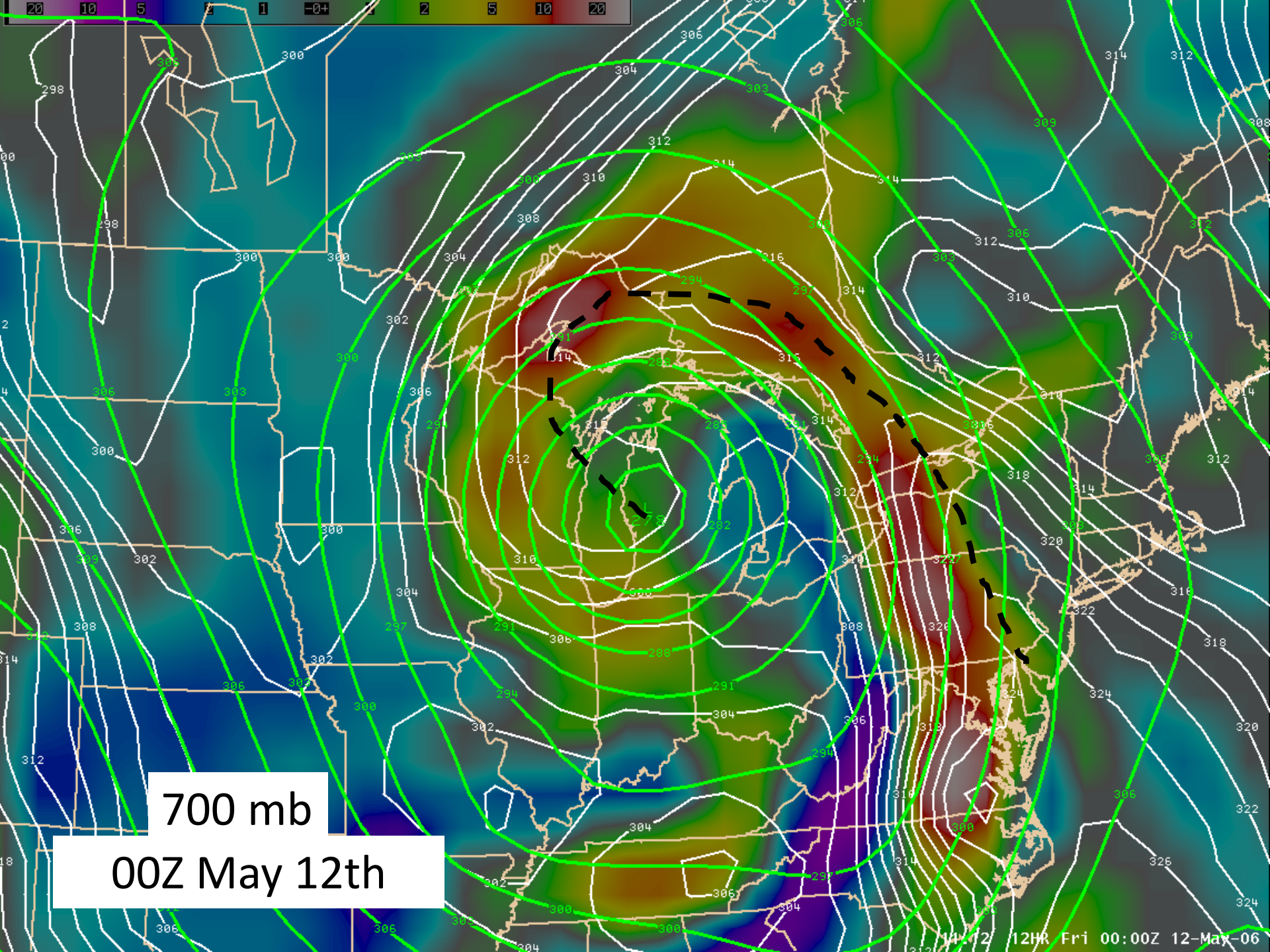
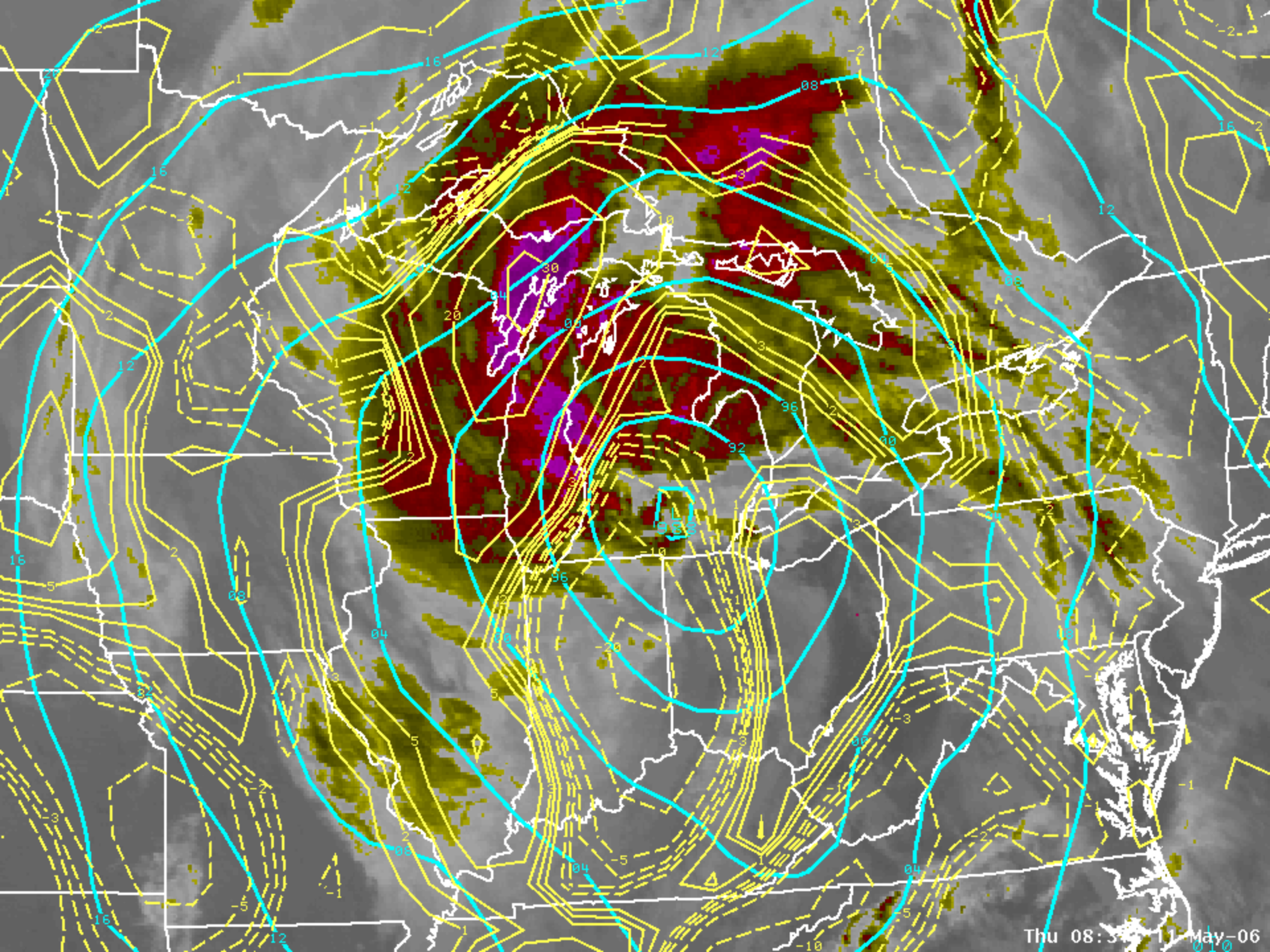

700 mb
00Z May 12th

Satellite View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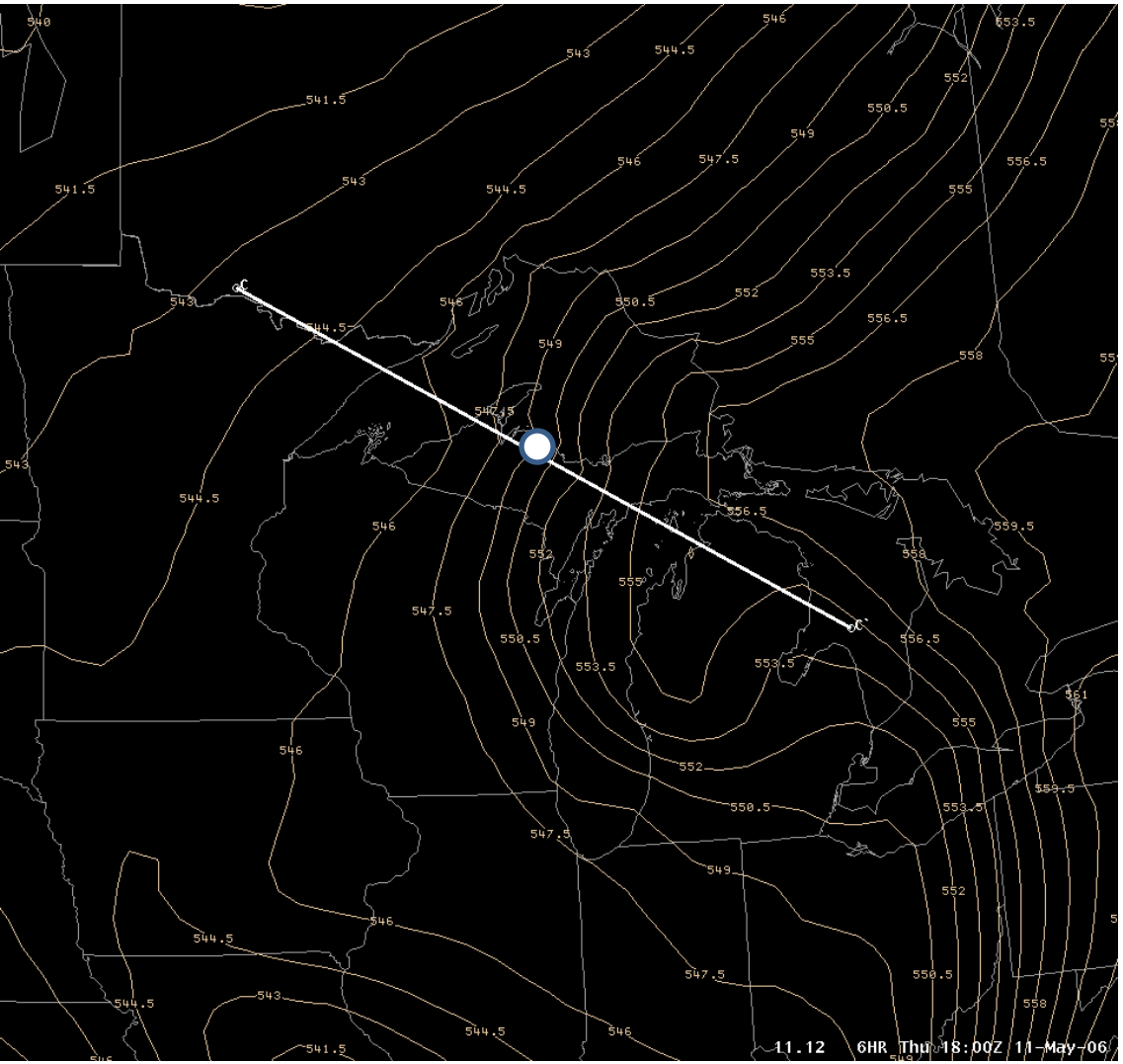
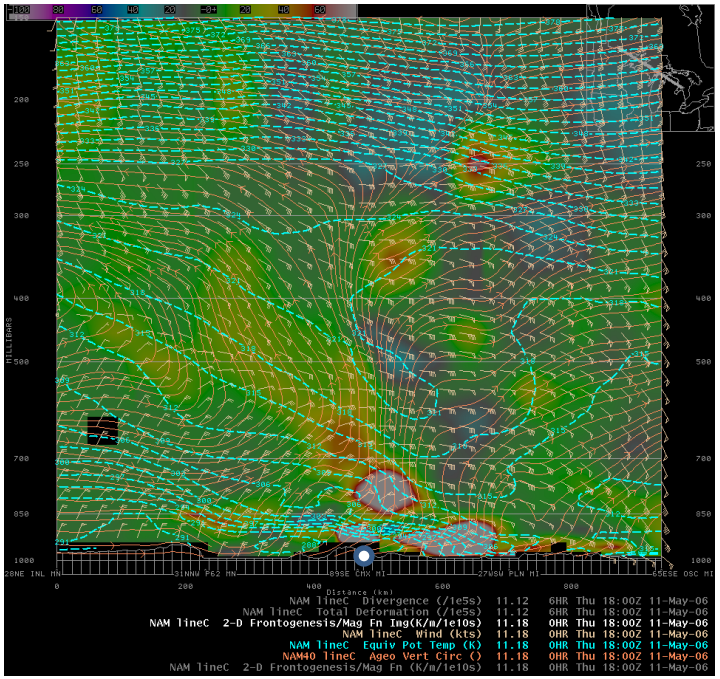
Cross Sections





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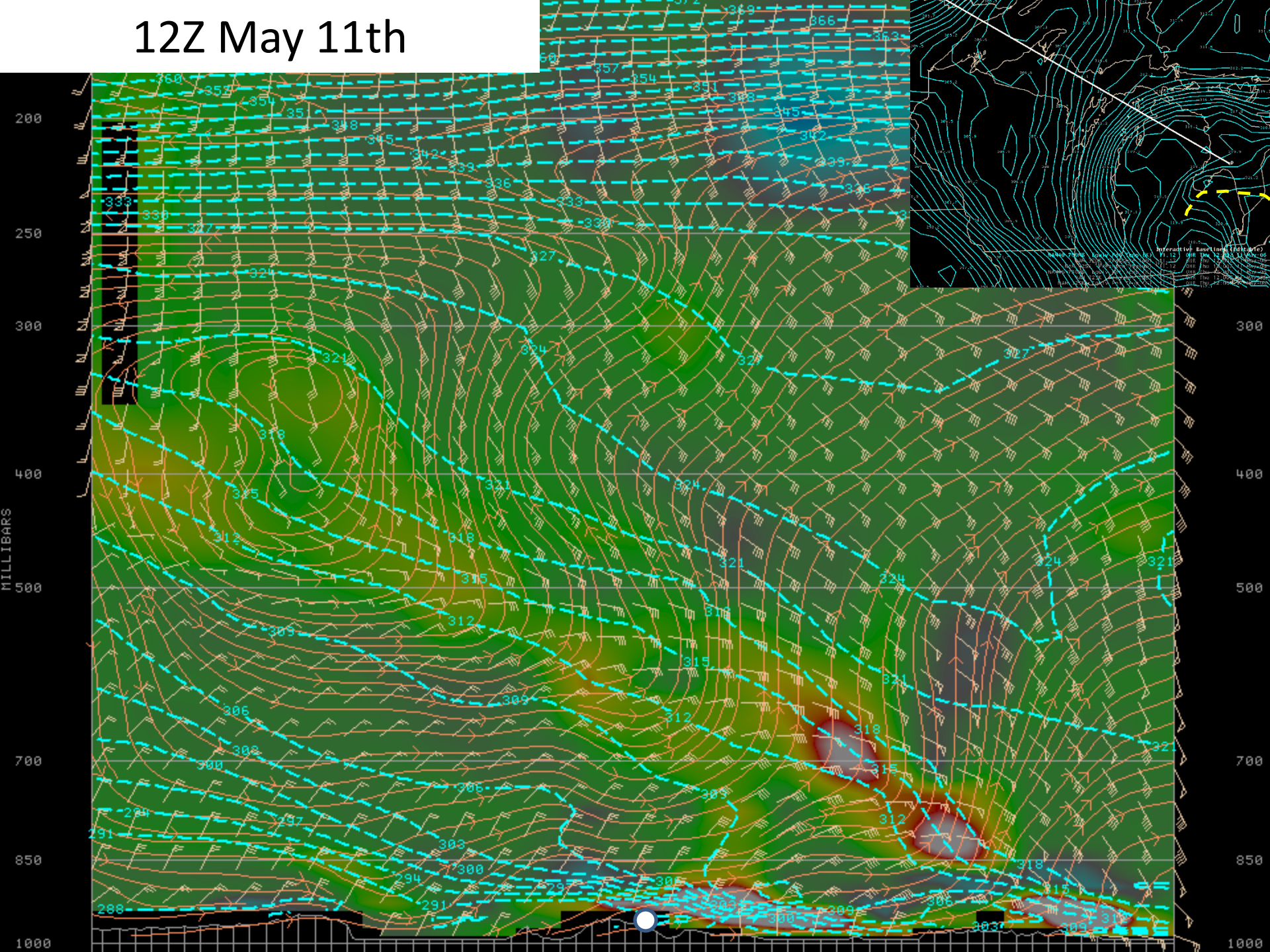

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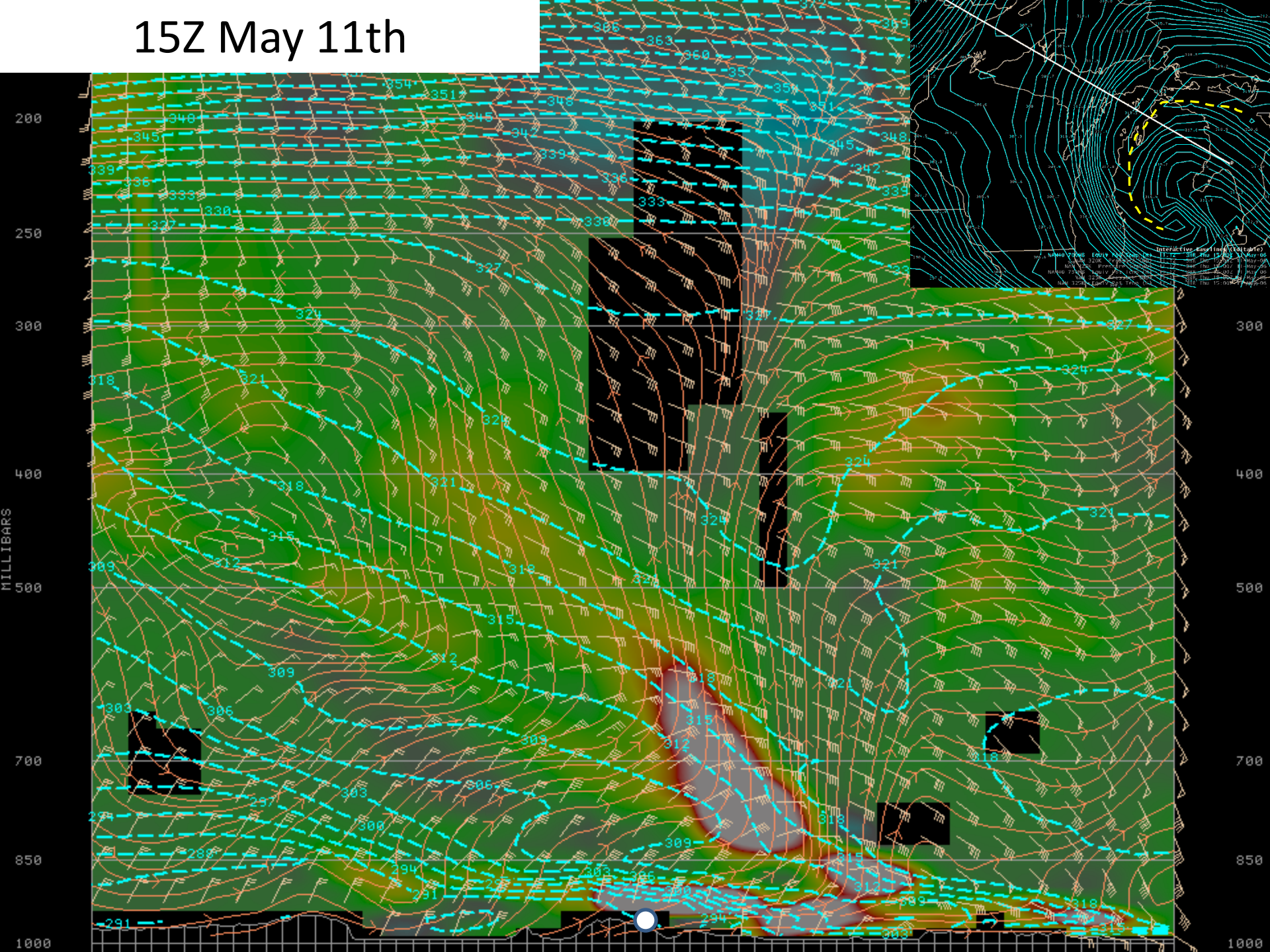

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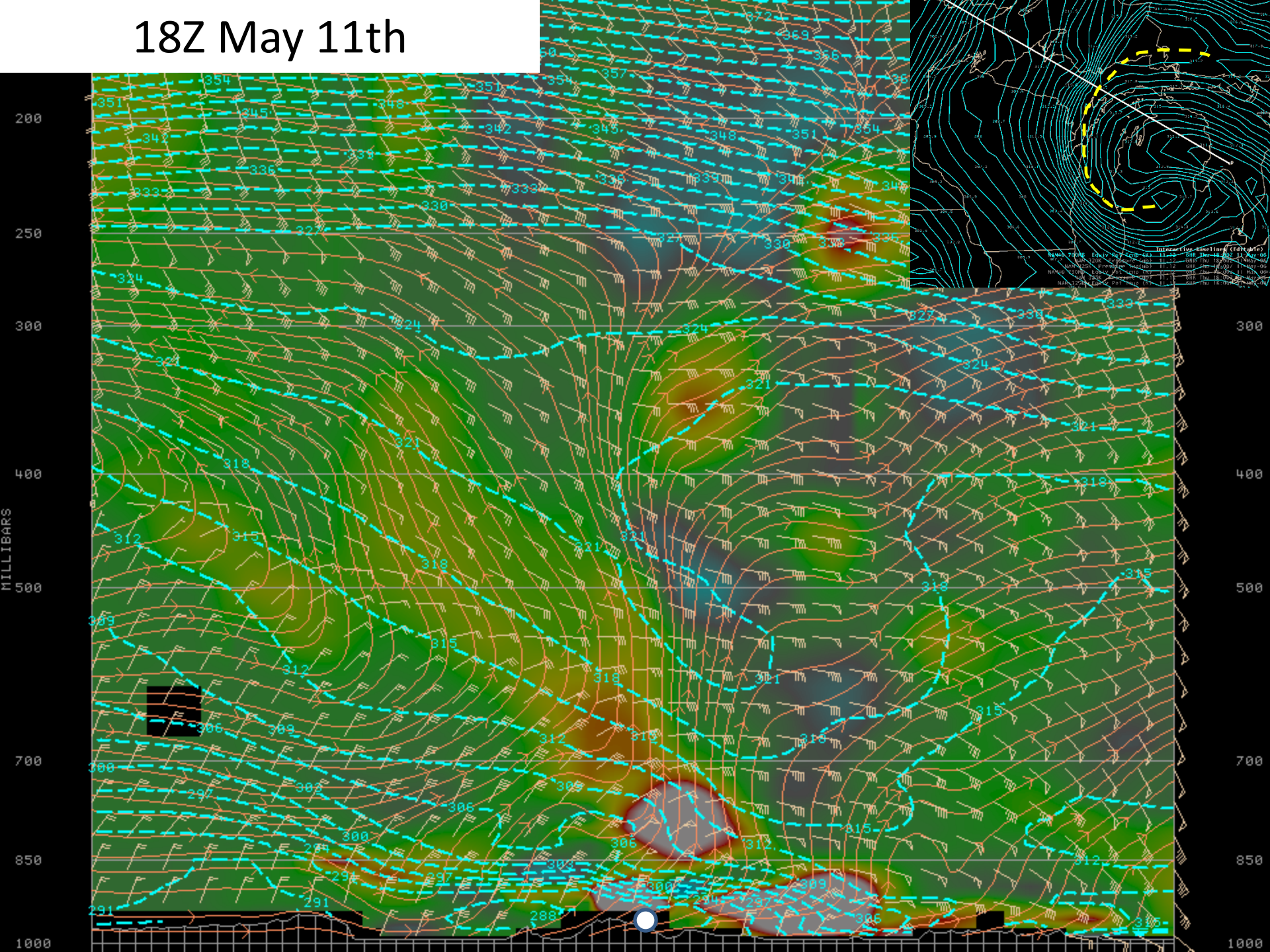

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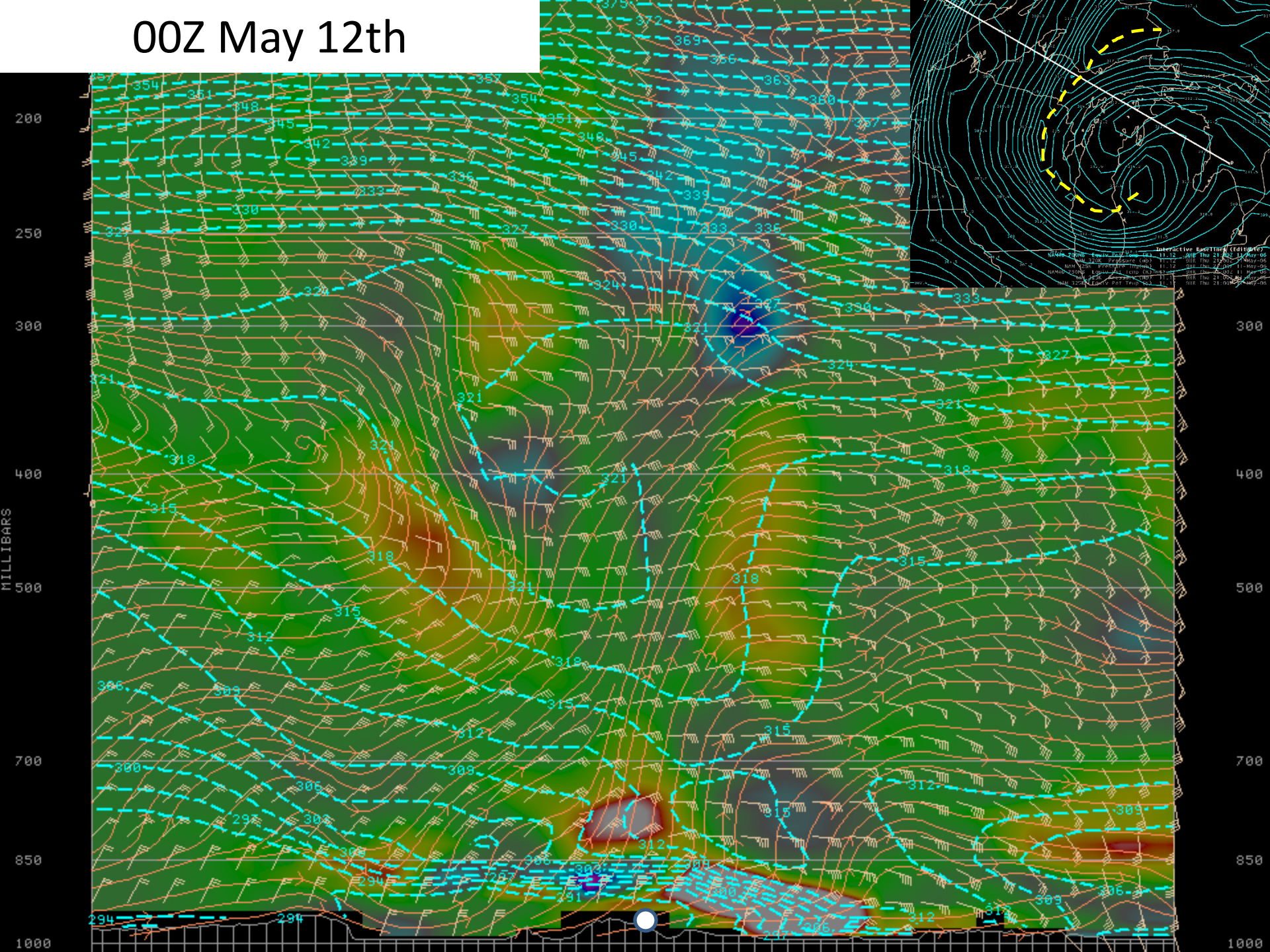

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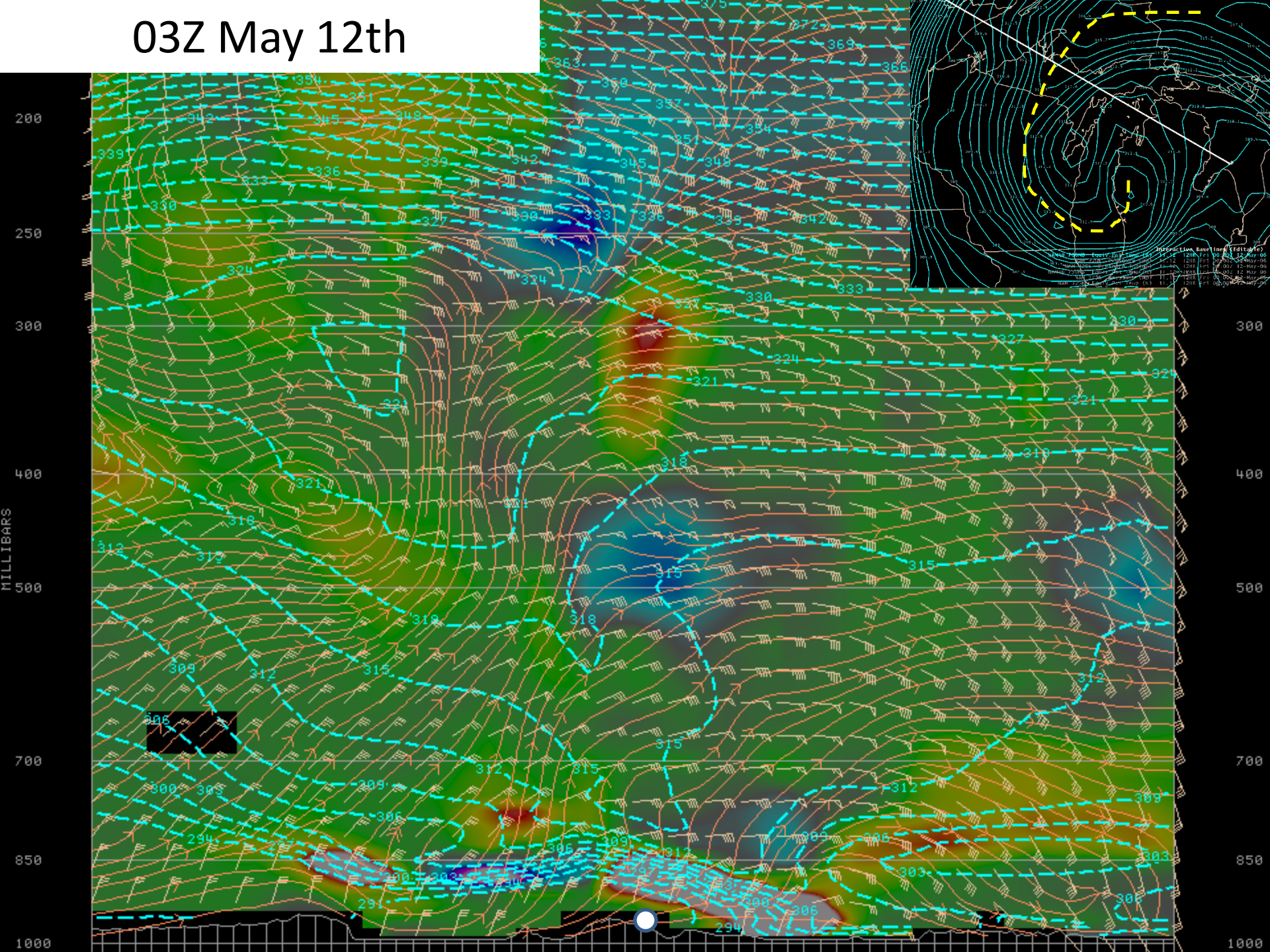

TROWAL

- A trough of warm air aloft (TROWAL) was observed within the occluded portion of the parent low.

- As the previous maps showed, this feature seemed to coincide well with an omega maxima over the areas where maximum precipitation was observed.

- 650mb F-gen band also lines up well with observed cloud top cooling seen in the IR loop.

- The cross sections showed, as the TROWAL moved over the area of interest, the low level frontogenesis increased.

Concluding Remarks

- As the cross sections and upper level maps showed, favorable conditions were in place for heavy precipitation to occur.

- In this event, the juxtaposition of following seem to have led to the intense heavy rainfall occurring:
  - TROWAL
    - Decreased static stability
    - Enhance mid/low level frontogenesis
  - Strong Upslope Flow
    - Probably the biggest contributor to heavy rainfall location.
  - Marginal lake enhancement
    - Not shown.

Concluding Remarks

- While most aspects of the forecast were recognized well by staff, the heavy rainfall was overlooked.

- Seasonal change in forecast mentality can cause this to happen.
  - Changing from “cold season mode” to “warm season mode”.

Concluding Remarks

- The goal of this presentation was to present a general overview of the case.
- After starting this presentation I realized quickly there is a lot more that can be done.
- Further study is needed, as there appear to be numerous dynamical processes going on.
  - Upper level jet contributions

References

- Martin J. E., 1999: Quasigeostrophic forcing of ascent in the occluded sector of cyclones and the trowal airstream. *Mon. Wea. Rev.*, **127**, 70–88.

- Martin J. E., 1998a: The structure and evolution of a continental winter cyclone. Part I: Frontal structure and the occlusion process. *Mon. Wea. Rev.*, **126**, 303–328.

- Grim, J. A., 2007: Mesoscale Dynamics of the Trowal and Warm-Frontal Regions of Two Continental Winter Cyclones. Mon. Wea. Rev,. **135**, 1647-1670.